Developing Air Force Systems Engineers—a Flight Path

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Throughout my career, I have observed a dilemma that faces program managers (PMs). How does a PM develop junior-level engineers into effective systems engineers? My first assignment in the Air Force as a second lieutenant was as a systems engineer responsible for depot maintenance of a $500 million, one-of-a-kind weapon system. I was part of an integrated product team (IPT) that managed the work of a defense contractor. We provided technical oversight, long-term sustainment strategy, and contractual support. For more than a year, I was the only government engineer on the program and thus the sole person responsible for technical oversight of 10 to 20 projects at a time. I reviewed and approved drawings, attended design reviews as the lead engineer, supervised installations, and

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performed developmental test and evaluation (DT&E). Clearly, I was a junior engineer in a senior engineer's position. I was provided no systems engineering training or applicable system-specific training by my unit. Now, after 6 years as a systems engineer and PM, I have learned this is not uncommon.

Although developing systems engineers from the entry-level stage of their careers has many advantages, the way it was implemented in my unit carries a number of risks. Primarily, the junior-level engineers likely have no training in systems engineering (which is not often taught in a traditional engineer discipline's college curriculum). The junior engineers probably have no significant training or experience involving the particular system they are assigned to manage. For example, I was assigned to a phased-array radar—a highly specialized field—and received no system-specific training before being unleashed on the contractor as the primary technical representative for the program. Junior-level engineers put in this position face a difficult situation. They have no experience to draw on in making technical decisions, no training in systems engineering to help them fully understand the job requirements, and little to no understanding of the particular system in which they are asked to provide technical oversight.

Although the Air Force assigns entry-level systems engineers to program offices, this is not a traditional career path for systems engineers. In many industries, engineers are promoted to a systems engineering position from a more specialized role, such as project engineer or design engineer. Typically, the engineer might have significant experience working on various subsystems. This approach has a number of merits—most notably, that it avoids putting a junior engineer in a senior engineer role. However, it also has disadvantages. The project engineer who is promoted into a systems engineer role probably also lacks any systems engineering expertise. In addition, systems engineering is a technical leadership discipline, rather than a technical discipline. The assumption that the best project engineer in an organization will make the best systems engineer is known as the "halo effect" and is to be avoided.

Finally, there is a contrast between the perspective of a systems engineer and a design or project engineer. Design engineers usually are specialists, and systems engineers are generalists. The two disciplines are accustomed to viewing problems from different perspectives. Specialists generally see the world through the lens of their own specialty. To paraphrase Abraham Maslow: If all you have is a hammer, everything looks like a nail. Systems engineers are supposed to take a different approach to problem solving called "systems thinking," the "systems approach," or the "systems perspective." A systems engineer must be able to zoom out and view the problem as a whole. This typically does not require specialized skills in any particular specialty but a solid foundation on the entire system, its mission requirements, and how the subsystems interface with each other. Systems thinking is a difficult skill and can take many years to master.

Other armed Services take an approach different from that of the Air Force regarding military personnel working in a program office. Military members are required to complete an operational assignment prior to being assigned to a program office. The advantage to this approach is that the engineer has some user experience to draw on and some credibility with the user he supports. However, the disadvantages are similar: The systems engineer has little engineering experience and little specialized systems engineering training.

The Air Force approach to developing systems engineers is not typical, but it has many advantages if done properly. First, systems engineers can be trained early in their careers in systems engineering practices and techniques. They can receive specialized training for the system they are assigned to, if necessary. They can develop their systems-thinking skills throughout their careers. By the time they are senior-level systems engineers, their systems engineering skills likely will be highly developed, compared with those of their specialist counterparts. Furthermore, their technical leadership skills will be well-developed, putting them in a good position to succeed. As junior-level employees, the skill assessment used to evaluate them for promotion will more closely align to the skills necessary for their new jobs. A successful junior systems engineer may be more proficient in the skills needed to become a successful senior systems engineer than an equally successful project engineer. This helps to minimize the halo effect.

If the development plan is carefully crafted, the Air Force methodology can be highly effective in producing first-rate systems engineers. The single most effective technique to developing highly skilled systems engineers is to have senior systems engineers capable of mentoring the junior staff and willing to do so. Mentors can provide invaluable guidance, wisdom, and technical know-how to the junior engineer. A mentor can provide guidance on organizational processes and professional best practices and may have specific knowledge of the system being worked on.

The organization I worked in as a junior systems engineer (in a senior systems engineer role) had very little to offer in the way of mentoring. There was a "mentor program" that was given lip service, but the junior engineers received very little in the way of mentorship. Part of the problem was the lack of senior technical staff, which meant the pool of potential mentors was small to begin with and staff members often too busy with their own work to help the junior staff. However, this was because mentoring, despite getting much lip service in meetings, was not really considered part of the senior engineers' job—and was therefore a lower priority.

To remedy this situation, senior staff members must understand that mentoring the junior staff is a high priority. It should be expected that they spend some time and energy

helping develop junior systems engineers into seasoned journeymen in their trade. This must be instilled in the organizational culture and considered a necessary and important part of the job description of a member of the senior systems engineering staff.

Entry-level engineers in the Air Force are provided a minimal amount of training to support their development as systems engineers. They take the DAU coursework (SYS 101, ACQ 101, etc.), which is a helpful introduction to the defense acquisition framework and the field of systems engineering. However, every organization implements this framework and these systems engineering tools differently. Furthermore, many (perhaps most) program offices are involved only in a smaller portion of the framework and use only a subset of the methods described in these courses. One organization may perform research and development and spend all its time pre-Milestone A. Others might be supporting operations, and spend much of their time in a totally different acquisition environment. More specific training in the actual tools and techniques used in each of these organizations is a big benefit.

Having the senior systems engineering staff provide training to the rest of the systems engineering group on a weekly or monthly basis may be effective. I have seen organizations hold monthly brown-bag lunches, in which a senior engineer gives a presentation on a relevant topic. One session would discuss "software engineering best practices." The next would cover "requirements engineering." After the presentation, everyone would share ideas. The junior systems engineers asked questions and sought advice on related or unrelated topics.

Another important aspect of training is providing opportunities for junior systems engineers to learn about the actual system they work on. These training opportunities can be in the form of brown-bag lunches, a formalized training program, or continuing education courses. Many PMs do not have a good understanding of what is taught in engineering school. Therefore, it is difficult for them to determine what an entry-level engineer already knows and in what areas he or she may require training.

I work as a systems engineer at a ballistic missile test range. After arriving, I went through a series of 14 orientation lectures conducted by the senior staff, to provide me with domain-specific training on radar theory, orbital mechanics, ballistic missile trajectories, as well as job-specific functions (e.g., how to use a particular software program).

A key enabler to implementing this type of mentoring and training is the organizational structure. In my experience, having worked in all three basic organizational structures (projectized, matrix, and functional), projectized organizational structures are the most difficult environments in which to develop systems engineers. This is because mentoring and training are, literally, not part of the senior systems engineering staff's job description—unless, of course, a large number of systems engineers are on staff under a single project. Matrix and functional organizations give the entire systems engineering staff a connection to each other in the organization, which facilitates knowledge sharing and mentoring. Of course, there are other advantages and disadvantages to each organizational type that won't be discussed here.

Entry-level systems engineers, having no experience, lack credibility. Therefore, putting them in senior-level positions should be avoided. That is not to say they shouldn't be empowered and/or given responsibility—just that they should not be put into a position to "crash and burn." When I started out, I was told by my PM, "We are going to throw you in the water and see if you can swim." Although this was a great opportunity for me, it can lead to disaster for both the organization and the junior systems engineer's professional career. Junior-level employees, generally, are not sufficiently developed professionally to be given this level of responsibility. It is imperative that organizations carve out low-risk positions and tasks that can be accomplished by junior engineers so they learn the ins and outs of the organization, acquire the knowledge and skills required to perform more difficult tasks, gain confidence, develop leadership skills, and earn credibility with their coworkers and colleagues.

Hiring entry-level systems engineers in defense acquisitions and developing them into senior systems engineers has a number of advantages. From the first day of their careers, they are learning to be systems thinkers rather than specialists and are developing their technical leadership skills. Developing technical *leadership* skills early helps diminish the "halo effect"—when great technical employees get promoted to leadership positions and their great technical performance does not translate to equally great leadership performance. Gaining the ability to see the big picture prevents the "Maslow's hammer" perspective and produces better decision makers and problem solvers.

To reap the benefits of these advantages, program offices must avoid the pitfalls of having junior systems engineers working on their staffs. The career of a junior systems engineer with too much responsibility, too little credibility, too little training, or no mentor can be fraught with peril. Junior systems engineers must be put in a position to succeed. They must be empowered and given responsibility for tasks that are consistent with their capabilities. The organization must have a culture that facilitates mentoring and a pool of senior systems engineers available to provide guidance. Junior systems engineers need to receive domain-specific training to enable them to effectively perform their duties. This training can be accomplished internally or externally. Providing sufficient training, mentoring, and a level or responsibility equal to the junior systems engineers' capabilities will go a long way toward avoiding these pitfalls and developing systems engineers into seasoned, journeyman-level technical leaders in an organization.

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